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DOI: <https://doi.org/10.1007/s00246-012-0405-6>

Posted at the Zurich Open Repository and Archive, University of Zurich

ZORA URL: <https://doi.org/10.5167/uzh-74249>

Journal Article

Published Version

Originally published at:

Quandt, Daniel; Knirsch, Walter; Niese, Oliver; Schraner, Thomas; Dave, Hitendu; Kretschmar, Oliver (2013). Impact of chest x-ray before discharge in asymptomatic children after cardiac surgery-prospective evaluation. *Pediatric Cardiology*, 34(1):155-158.

DOI: <https://doi.org/10.1007/s00246-012-0405-6>

Impact of Chest X-Ray Before Discharge in Asymptomatic Children After Cardiac Surgery—Prospective Evaluation

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Received: 15 April 2012 / Accepted: 19 May 2012 / Published online: 13 June 2012
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Abstract In many paediatric cardiac units chest radiographs are performed routinely before discharge after cardiac surgery. These radiographs contribute to radiation exposure. To evaluate the diagnostic impact of routine chest X-rays before discharge in children undergoing open heart surgery and to analyze certain risk factors predicting pathologic findings. This was a prospective (6 months) single-centre observational clinical study. One hundred twenty-eight consecutive children undergoing heart surgery underwent biplane chest X-ray at a mean of 13 days after surgery. Pathologic findings on chest X-rays were defined as infiltrate, atelectasis, pleural effusion, pneumothorax, or signs of fluid overload. One hundred nine asymptomatic children were included in the final analysis. Risk factors, such as age, corrective versus palliative surgery, reoperation, sternotomy versus lateral thoracotomy, and relevant pulmonary events during postoperative paediatric intensive care unit (PICU) stay, were analysed. In only 5.5 % (6 of 109) of these asymptomatic patients were pathologic

findings on routine chest X-ray before discharge found. In only three of these cases (50 %), subsequent noninvasive medical intervention (increasing diuretics) was needed. All six patients had relevant pulmonary events during their PICU stay. Risk factor analysis showed only pulmonary complications during PICU stay to be significantly associated ($p = 0.005$) with pathologic X-ray findings. Routine chest radiographs before discharge after cardiac surgery can be omitted in asymptomatic children with an uneventful and straightforward perioperative course. Chest radiographs before discharge are warrantable if pulmonary complications did occur during their PICU stay, as this is a risk factor for pathologic findings in chest X-rays before discharge.

Keywords Congenital cardiac surgery · Postoperative management · Radiation

Introduction

In many paediatric cardiac units chest radiographs are performed routinely before discharge after cardiac surgery in order to improve patients' safety. However, these radiographs contribute to radiation exposure of these children. Taking into account that many paediatric cardiac patients face further examinations (including multiple chest radiograph examinations, cardiac catheterization, or computed tomography scanning) during their lifetime, keeping the total amount of performed chest radiographs to a necessary minimum should be an important aim in clinical practice. Furthermore, children have higher radiosensitivity compared to adults, mainly because of their growth potential, their increased vulnerability of any exposed body tissue, and their longer life expectancy [2, 3, 6, 7]. Every additional radiation exposure means an increase in the

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likelihood for long-term complications, including malignoma, during the paediatric patient's lifetime [6]. Therefore, indications for chest X-rays should be restrictive, and the impact of every routine examination should be questioned by the clinician.

For adult cardiac patients, several investigations have questioned the benefit of routine chest X-rays after cardiac surgery. Rao et al. [5] showed that routine radiographs were not essential to monitor the satisfactory progress of adults recovering after cardiac surgical procedures. Mets et al. [4] showed that no therapeutic consequences were caused in such patients by eliminating some of the routine chest radiographs performed during their intensive care unit stay. To our knowledge, there is only one study in the literature examining the impact of chest radiograph before discharge in paediatric cardiac patients [1]. This group concluded that routine chest X-rays before discharge can be omitted in paediatric cardiac patients. Because the mentioned study was a retrospective survey and the patient collective was rather small, it was not possible to identify possible risk factors during hospital stay and postoperative course that might predict pathologic findings and therefore indicate a "routine" chest radiograph before discharge.

The aim of our study was to evaluate the diagnostic impact of routine chest radiograph before discharge in children undergoing open heart surgery. A prospective study design was used to allow for analysis of certain possible risk factors during the postoperative course to predict pathologic findings in radiograph before discharge.

Methods

In a prospective (6 months) single-centre observational clinical study, 128 consecutive children undergoing heart surgery underwent biplane chest X-ray at a mean of 13 days (range 1–64) after surgery and before planned discharge. Median age of the patients was 6 months (range 0–17.9 years). There were 28 newborns, 45 patients <1-year-old, and 54 patients >1-year-old; 69 patients were male.

Patients were included regardless of the underlying cardiac pathologies and the surgeries performed, meaning that the study group was heterogeneous in terms of

Table 2 Definition of relevant pulmonary events during PICU stay

Pulmonary infection
Pleural effusion
Atelectasis
Pneumothorax
Multiple complications

underlying cardiac morphology and thus represented the normal patient collective at a major paediatric cardiac surgery centre in Europe (for patients surgical characteristics see also Table 1). In our centre, the full range of surgeries, including implantation of assist devices as well as heart transplantation, for all types of congenital heart disease is routinely performed. Patients after an operative epicardial implantation of a cardiac pacemaker were excluded from the study because routine chest X-ray in our unit is indicated and performed in these patients to control and document correct position of the pacemaker aggregate as well as the integrity of pacemaker leads. One patient was excluded because no routine chest X-ray before discharge was performed.

Of the 128 patients included in the study, 109 were asymptomatic at the time of the "routine" chest X-ray before discharge and were therefore included in the final analysis. Eighteen children still had pulmonary symptoms (e.g., persistent tachypnea) and therefore had a clinical indication for their radiograph; thus, they were excluded from further risk factor analysis. We defined possible risk factors for pathologic findings in X-rays before discharge, which were analysed statistically. These risk factors included age, corrective versus palliative surgery, reoperation, cardiac surgery with cardiopulmonary bypass, sternotomy versus lateral thoracotomy, and relevant pulmonary events (defined as pulmonary infection, pleural effusion, atelectasis, and pneumothorax during postoperative PICU stay) (Table 2). Statistical analysis was performed using Chi-square test and logistic regression analysis for group comparison. Pathologic findings in chest X-rays were defined as infiltrate, atelectasis, pleural effusion, pneumothorax, or signs of fluid overload/pulmonary hypercirculation (Table 3). The therapeutic consequences were documented. The study was approved by the Ethical Commission of the University Children's Hospital Zurich.

Table 1 Patient surgical characteristics

Patient characteristics	Yes	No
Corrective surgery	100	27
Reoperation	42	85
Cardiopulmonary bypass	106	21
Sternotomy	98	29
Relevant pulmonary events during PICU stay ^a	56	71

^a See definitions in Table 2

Table 3 Definition of pathologic findings on X-ray before discharge

Infiltration
Atelectasis
Pleural effusion
Pneumothorax
Signs of pulmonary congestion

Results

In 5.5 % (6 of 109) of asymptomatic patients, pathologic findings on routine chest X-ray before discharge were found. The pathologic findings in X-ray before discharge are listed in Table 4.

In only three of these six cases (50 %) noninvasive medical intervention (dosage increase of diuretics) was needed. The indication for this was exclusively based on the radiograph showing signs of pulmonary congestion, although these patients clinically were completely asymptomatic. During follow-up diuretic therapy was ceased in all three patients within 1–3 months after surgery on a clinical basis without repeating radiography.

Interestingly, all six of these patients with relevant findings on chest radiograph before discharge had some kind of relevant pulmonary event during their PICU stay. Risk factor analysis showed only relevant pulmonary events during PICU stay to be significantly associated ($p = 0.005$) with pathologic radiograph findings before discharge. Logistic regression analysis of 127 patients, also including the 18 symptomatic children, showed this effect to be stable ($p = 0.037$). Other possible risk factors did not show significant influence (Table 5).

Eighteen of 127 radiographs performed before discharge were clinically indicated because these children still had some kind of clinical relevant pulmonary symptoms (e.g., persistent tachypnoe, etc.). Of these 18 patients, a higher rate of children (10 of 18 [56 %]) also had relevant pulmonary events during PICU stay.

Discussion

Our prospective study was able to demonstrate that only a small percentage (5.5 %) of routinely performed chest radiographs before discharge were of clinical relevance, and even a smaller rate influenced therapeutic management (3.5 %). These findings are mostly congruent with the results of the retrospective analysis of Bosse and Krasemann, who found only 5.6 % of all radiographs performed

Table 5 Risk factor analysis^a showed only relevant pulmonary events during PICU stay to be significantly associated with pathologic radiograph findings before discharge

Factor	<i>p</i>
Age	NS
Corrective surgery	NS
Reoperation	NS
Cardiopulmonary bypass	NS
Sternotomy	NS
Relevant pulmonary events during PICU stay	0.037

NS not significant

^a Logistic regression analysis

immediately before discharge to result in a change in therapeutic management [1].

Therefore, we believe that it is highly questionable to perform chest radiograph before discharge in children after cardiac surgery on a routine basis. If a chest radiograph is still wanted as an optional “quality-control” measure, it seems to be rather inappropriate in asymptomatic children without any relevant pulmonary events during their postoperative course. Risk factor analysis showed relevant pulmonary events during PICU stay to be significantly associated ($p = 0.037$) with relevant findings on chest radiograph before discharge. We want to highlight that all of these children were asymptomatic before discharge. Furthermore, only little therapeutic consequences arose from the chest radiographs before discharge.

One explanation for the correlation between relevant pulmonary events during PICU stay and relevant findings on radiograph before discharge might be that residual findings after postoperative pneumonia or atelectasis might still be visible on the radiograph before discharge. Again, because these children were asymptomatic at the time of discharge and performance of the chest radiograph, we believe that this is of little clinical relevance.

Analysis of the 18 patients with pulmonary symptoms at discharge showed a greater number of children (10 of 18) who also had relevant pulmonary events during their PICU stay. These calculations did not reach significant levels (and the subgroup is small), but the tendency with a higher rate of children having relevant pulmonary events during PICU stay supports the strategy to major attention on the children having had a complicated pulmonary PICU stay after cardiac surgery. Those children with a straightforward uncomplicated postoperative course and who are asymptomatic at the time of discharge do not benefit from a routine chest radiograph before discharge. In children who have pulmonary complications during their PICA stay, a chest radiograph before discharge might be justifiable.

Table 4 Number of patients with relevant findings on chest radiograph before discharge

Pathologic findings	<i>N</i>
Infiltration	0
Atelectasis	1
Pleural effusion	1
Pneumothorax	1
Signs of pulmonary congestion	3

Our study is also supported by investigations in adult patients. Rao et al. [5] concluded that chest radiographs should only be performed when clinically indicated in satisfactorily recovering adult cardiac surgical patients. In view of our results and the findings of other groups, we believe that only clinically indicated radiographs should be performed. If any other imaging modality is available (e.g., sonography for pleural effusion) with respect to decreasing radiation exposure, alternative imaging modalities than radiographs should be used.

On the basis of our study and the retrospective work of Bosse and Krasemann [1], we believe it would also be safe to perform in the future a prospective, randomized, and blinded study in children after cardiac surgery examining the usefulness of radiographs during the postoperative course, comparable to the study of Rao et al. [5] in adults.

Conclusion

The performance of routine chest radiographs before discharge after cardiac surgery can be omitted in asymptomatic children with an uneventful and straightforward perioperative course. Chest radiographs before discharge are warrantable if pulmonary complications did occur

during their PICU stay, as this is a risk factor for pathologic findings in chest X-rays before discharge.

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